Abstract:
Optical instruments become more and more popular due to their versatile, nondestructive, and fast measurement capability. For quantitative measurement these instruments have to be traced back to the SI unit of metre. Instrument manufacturers realize this traceability in general by verification of the 3 spatial axes (X, Y and Z) separately, by using calibrated line scales as lateral standards and gauge blocks as vertical standards to generate individual correction terms for each axis.

Our contribution will show on examples that this procedure is not sufficient for precise 3D measurement and has to be improved, as e.g. the neglected volume effects like deviations of the axes-rectangularity and aberrations in the beam path significantly influence the accuracy particularly of form measurements.

The majority of natural and artificial surfaces consist of a mixture of flat and more or less curved elements. Three-dimensional calibration standards like pyramidal multi-step structures (Fig. 1) do not only allow to calibrate the three axes, but to also check the orthogonality and to determine the coupling between all three axes in just one measurement [1]. Aberration artifacts (dashed line) shown in Figure 2 always occur at slopes and curvatures, influence the calculated surfaces and thus distort positions and shape. By use of curvature standards the measurement uncertainty can be identified and suitable uncertainty models are derived.

According to VDI/VDE 2655 – Part 1.3 we will present the implementation of a measurement scheme and recommend some standards to improve the calibration of optical instruments.

After application of these artifacts, optical instruments are able to calibrate form elements e.g. stylus apex radii with dimension from 2 µm to 5 µm (Fig. 3) down to sub-µm accuracy.

Figure 1: CLSM image of a pyramidal 3D standard
Size: 87 µm x 86 µm

Figure 2: Form artifacts due to aberration in optical instruments

Figure 3: CLSM image of a stylus tip
Image size: 32 µm x 32 µm x 12 µm